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# EMPLOYMENT IMPLICATIONS OF THE APPLICATION OF SCIENCE AND TECHNOLOGY IN LESS DEVELOPED AREAS

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# B.4 Employment Implications of the Application of Science and Technology in Less Developed Areas

by

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Unemployment and underemployment, as well as low man-hour productivity, are major characteristics of less developed economies. Low income countries, unfortunately, face a possible conflict between maximisation of output and maximisation of employment. In many of them capital is scarse and unskilled labour is redundant; they cannot afford to waste capital. To make matters worse, there is evidence that over a wide range of products the techniques which utilize a high ratio of labour to capital (or land) also involve a low ration of output to capital (or land). In other words, underdeveloped countries may be unable to adjust their technology to their factor endowments by adopting labour-intensive techniques; the most efficient organization of production in many fields may be capital intensive. Technical coefficients (proportions in which factors of production are used) may be subject to little variation without a sharp rise in the capital:output ratio. Moreover, technological progress of an essentially labour-saving nature, while raising man-hour productivity, may also raise the level of unemployment in face of a rapidly growing labour force. In considering the contribution of science and technology to raising productivity, therefore, the possible adverse effect on employment must also be taken into account.

Technological displacement is at least as old as the industrial revolution, and misgivings about the impact of scientific and technological progress on employment are equally old. Over the centuries fear of mass technological unemployment largely disappeared in the now advanced countries, although automation has revived this fear since World War II. There are, however, some important differences between the situation of less developed countries today and that of Europe, North America, and Australasia on the eve of their industrial revolutions.[1] Per capita incomes were relatively high, capital accumulation correspondingly easier. Ideology and social structures were more favourable to capital accumulation. Population:resource ratios were more favourable. Rates of population growth were lower. Expansion of world trade served as an "engine for growth" in a fashion unlikely to be repeated in the next few decades. Most important for purposes of the present discussion, the now advanced countries did not launch the process of transforming essentially agricultural into essentially industrial economies with a large backlog of unemployment and underemployment to absorb. Taken together these factors mean that solving simultaneously the problems of low productivity and income on the one hand, and unemployment and underemployment on the other, will require substantially higher ratios of investment to income in the now underdeveloped countries than those which did the job for the now advanced ones.

As stated by the ILO Expert Group on employment objectives in economic development,

> Incautious application of the experience of the more advanced countries is likely to result in an underestimation of capital requirements for employment creation. In the early phases of their development few countries in Western Europe faced the problem of absorbing such large numbers of underemployed and unemployed as exist today in some underdeveloped countries where, in addition to high rates of growth of the labour force, there have been for some decades very high rates of displacement of labour from agriculture and traditional industries... Rates of investment which were adequate to absorb the supplies of labour in various countries in the past may be wholly inadequate to meet the master problems of the present day.[2]

Income targets vs. employment targets

Development plans and programmes which may seem quite satisfactory in terms of targets set for rates of growth of per capita income may fail to bring acceptable reductions in under-and unemployment. Indeed, casting development plans in terms of income creation alone can result in the mere projection of past trends with respect to employment and unemployment. Brazil and Mexico, which have enjoyed high overall rates of growth since World War II without solving their employment problems, are cases in point. Even countries which have adopted employment-oriented palns, such as India and Italy, have found their plans too modest for the task. The second Five Year Plan in India had employment creation as a primary objective; indeed, it made it clear that if a conflict arose between maximising output and maximising employment the latter goal should have priority. Yet the rise in non-agricultural employment, estimated at 6.5 million, was less than half of the increase in the labour force in the same period: the bulk of the additional workers had to seek a livelihood in the already overcrowded agricultural sector. To quote the noted Indian economist K.N. Raj,

> Not only has the pace of development up to now been inadequate to cope with the growth of the working force resulting from the rise in population but, what is a more serious aspect of this failure, there has been no great success in mobilising idle labour in order to accelerate the tempo of development.[3]

The Italian 10-year plan, frequently referred to as the Vanoni plan, laid particular stress on employment creation in the South. It was hoped that gaps in per capita income as between North and South could thus be narrowed. During its first five years (1955-59) the Plan was successful in raising national income at an average rate of 5.5 per cent, slightly above target. It was also successful in establishing equilibrium in the balance of payments. However, investment continued to be concentrated in the North as before; while the percentage rate of growth of per capita income in the South was raised to about the same level as in the North, the gap in absolute levels of per capita income continued to increase. More important for present purposes, even Italy's concentrated effort succeeded only in cutting unemployment in half, and even this accomplishment was possible only because net emigration from the country almost equalled the decline in unemployment.

## Technological progress, employment, and dualism

The large scale migration to cities since World War II, has transported some share of the underemployment, unemployment and low productivity from a rural to an urban setting. Nevertheless, in most underdeveloped countries it is still the agricultural sector in which these problems are most acute. Investment has been concentrated in the "modern" sector: plantations, mines, oil fields, and the financing, transport, and processing operations associated with these. Because of the highly capital-intensive nature of this investment, it has provided less increase in employment than in output and exports. Yet it was accompanied by a "population explosion" because industrialization brought public health measures, law and order, and improved transport which reduced the dangers of famine. Thus the process of industrial investment meant rapid growth of the number of people who had to be employed in the other main sector: peasant agriculture and the small or cottage industries, plus the finance, transport, and processing connected with these, together labelled the "traditional" sector.

While good land was abundant the traditional sector could absorb increased numbers without a fall in per capita income or unemployment. But as good land gave out, diminishing returns to labor on the land, underemployment and work-spreading devices appeared in the traditional sector. Technological progress was increasingly confined to the modern sector, where skilled labor was scarce, while capital could be raised in world markets. Accordingly labor-saving innovations seemed worthwhile. In the traditional sector, where labor was redundant, there was no incentive for introduction of labor-saving devices. Productivity and incomes in the two sectors grew farther and farther apart. Sometimes the agglomerative pull of the leading sectors may become so strong that lagging sectors are converted into regressive ones. The problem is especially acute when sectors and regions overlap; identification of lagging and leading sectors with lagging and leading regions greatly complicates the task of reallocation of resources. In some countries the leading sector is identified with a few cities.

Under conditions of technological dualism it is possible to have very substantial investment in the modern sector, and quite satisfactory increases in per capita income in that sector, without making a real dent in the problem of unemployment and poverty in the traditional sector and region, as in Brazil, Italy and Mexico. Impressive though it is, the investment taking place in the modern sector does not provide new employment opportunities at a rate high enough to permit even a relative decline in the proportion of population living in the traditional sector and region, let alone to permit an absolute decline in population of that region.

In the worst cases the lagging sectors and regions are associated with less highly developed social groups as well. In these cases moving people from low-productivity occupations to more highly productive ones is not only a matter of moving them from one part of the country to another; it is also a matter of moving them from one socio-cultural framework to another. For a Brazilian peasnat in the Northeast or a Mexican peasant in the South both the geographic and cultural distances that many people must move to obtain jobs in the progressing sector of the society may be very great indeed.

Once technological and sociological dualism set in together, a "feedback" mechanism tends to appear. The pattern of emigration tends to dilute the quality of the population--without sufficiently reducing its quantity. The best educated, best trained, most progressive, most ambitious men and women leave the lagging region for the progressive one. Thus the lagging region is denuded of the very qualities needed to reconstruct it and reverse the trend. Meanwhile, at the other end of the migratory route, underdeveloped countries suffer from urban congestion, slums, urban underemployment and urban parasitism.

To some degree, then, the conflict between maximising income and maximising employment appears as a conflict between the wish to take advantage of the superior productivity of investment in the modern sector or leading region and the wish to create employment in the traditional sector or lagging region. The powerful agglomerative pull of leading regions usually reflects genuine advantages in terms of availability of training and skills, social overhead capital, access to raw materials, finance and markets. In many--if not most--cases additional investment in the already progressing sector and region will add more to national income than an equal amount of investment in the stagnant or retrogressing region. In terms of raising national income, the case for active intervention by government to shift investment from leading to lagging regions must rest on certain rather special condition: there must exist in the lagging region large-scale, "lumpy" investments of a kind not now attractive (under existing policies) to private enterprise; the investment projects must be of a kind which can be efficiently executed with relatively labour-intensive methods, (where the elasticity of substitution of labour for capital is high); and output:capital ratios must be higher for these undertakings than for any investment of equal size in the leading region. It is a question whether such cases appear very frequently.

It is also a question whether employment as such is ever a legitimate aim of public policy. No doubt it is good for morale to do a certain amount of work; but most people would happily accept more "underemployment" if their incomes were substantially raised at the same time. The ideal policy would maximize income and then distribute both income and leisure equitably among individuals, groups, and regions. Unfortunately it is not always possible--technically, administratively, and politically--to adopt this ideal policy; sometimes satisfactory incomes for the unemployed or underemployed in the lagging sector or region can be provided only through more or less full-time employemt, with a capital outlay that would produce substantially more output if it were utilized to create fewer jobs in the modern sector or leading region.

Technological progress, employment, and mobility

It is clear that taking full advantage of the opportunities provided by scientific and technological advance for raising incomes, without aggravating the employment problem, requires both an investment budget of considerable magnitude and sufficient occupational and geographic mobility. What is the danger that immobility of the labour force will prevent use of the most advanced techniques, even if the supply of capital is adequate? While a definitive answer to this question cannot yet be given, the accumulated evidence suggests that if attractive jobs, transport, and retraining facilities are available, socio-cultural impediments to mobility can be overcome fairly easily in most countries.[4]

It is important in this context to distinguish between mobility and movement. The question is whether an observed lack of movement from low productivity occupations and regions to higher ones results from social institutions and individual attitudes causing unwillingness to move for a given percentage increase in income--which would be the proper interpretation of "immobility"--or whether the lack of movement reflects a simple lack of employment opportunities in the higher-productivity sector and region. The apparent high "mobility" of the United States labor force, for example, may simply reflect the fact that employment opportunities in expanding sectors and regions have been more continuously available throughout the history of the United States than in other countries. It is true that in some expanding industrial centers, such as Sao Paulo, Medellin, Manila and Caracas there is an apparent scarcity of skilled workers. The underemployed villagers, on the other hand, are not skilled. A major factor in the inadequate movement from low productivity to high productivity sectors and regions may be a persistent exaggeration by industrial managers and government officials of the cost and difficulties of training or retraining workers coming from the rural sectors.

Mobility and training

Occupational mobility contributes greatly to geographic mobility, and education and training contribute greatly to occupational mobility. Indeed, the provision of requisite facilities for education and training is probably the most important single policy for reaping the benefits of scientific and technological progress, while at the same time reducing underemployment and unemployment. One word of caution is necessary here, however. It is sometimes suggested that the efficient way to determine the education component of a development programme is to translate the targets for output of goods and services in the development plan into manpower requirements, and to translate these in turn into educational requirements on the basis of relationships developed by education planners. This method is imperfect for two reasons. First, it leaves out of account the value of education as a "consumers' good." Second, the product-mix itself, should not be determined irrespective of educational requirements for production of various goods and services. The composition of the target product-mix, and of the investment programme undertaken to achieve it, must depend in part on the relative cost of the various types of educational programmes needed. At the same time, the pattern of education must be related, at least in part, to the production requirements of the development programme. In short, investment in education and in all other sectors of the development programme should be mutually determined.

Product mix vs. choice of technology

The amount of employment created by a given volume of investment depends in part on the product-mix, and partly on the technology chosen to produce the various goods and services in the product-mix. At first blush, it would seem that underdeveloped countries where capital is scarce and unskilled labour redundant can keep the aggregate capital:output ratio down, without undue loss of efficiency, more easily through choice of product-mix than through choice of technology. If it is difficult to produce a wide range of commodities efficiently with labour-intensive methods, can't developing countries specialize in those products where efficiency is possible with a relatively high labour:capital ratio? The answer, unfortunately, is "not

always." The countrys resource pattern may be such that its comparative advantage in international trade may lie in industries that require relatively capital-intensive techniques--oil, tin, bauxite, copper, and plantation agriculture, for example. The balance of payments situation may be one strongly favouring the development of import-replacing industries, of a capital-intensive nature. The subtle factor of "linkage"--stimulation of investment in other fields by initital investment in one field--may be higher for heavy, large-scale, capital-intensive industries than for light, small-scale, or labour-intensive industries. Acquisition of fundamental technical and managerial skills, "technology-mindedness" and "development mindedness", any be more closely associated with modern technology of a capital-intensive nature than with old fashioned technology of a labour-intensive type.

Very little research has been done on choice of technology for particular undertakings. The complexity of the analysis that must be undertaken before one can be sure which technique is best has been admirably set forth by the Indian economist A.K. Sen.[5] In addition to the capital:output ratios for the whole range of available techniques, one needs to have information regarding labour costs at present and probably future wage rates; working capital requirements; quality and price of the product with different techniques; managerial costs; surplus available for reinvestment; impact on the balance of payments; linkage effects; and even--since the time-pattern of exapnsion of output will be different for different techniques--communal time-preference functions.[6] Applying his analytical framework as best he could with the data available, Sen came to the conclusion that "the case for hand looms or for power looms is much less straightforward than the Hand Loom Board of India on the one hand and the Millowners' Association of Bombay on the other seem to suggest."[7] His calcualtions show that the Banaras hand loom has higher output; capital ratio; but the rate of surplus is so much higher with the nonautomatic power loom that with reinvestment of the surplus total output with the power loom will surpass that of the hand loom within six years. Dr. Sen is much more definite regarding the Ambar Charkha spinning-wheel: "As a technological possibility, the Ambar Charkha seems to offer very little."[8]

Dhar and Lydall present Indian data which suggest a general tendency for output:capital ratios to rise with size of factory. The Netherlands Economics Institute has gathered statistics for several manufacturing industries in the United States, Mexico, Colombia and India which indicate a wide range of possible capital:labour ratios in these industries, but except for cotton textiles and bakery products the capital cost per job is high in all countries--above $2,000. A United Nations study for France, India, Poland and U.S.S.R. shows a relatively narrow range of capital:output ratios, with a much wider range of capital:labour ratios, resulting in almost equal costs per cubic metre-kilometre for a combined operation of excavation, transport, and compaction.[9] On the whole, however, both the quantity and quality of such data are inadequate for any general conclusions about the potential use of labour-intensive technology.

More important, there has yet to be any large-scale, systematic scientific and engineerng research into the possibilities of new techniques which, hopefully, may have both low capital:labour rations and low capital:output ratios. Such research has been concentrated to date in advanced countries where capital is relatively abundant and labour relatively scarce, so that labour-saving innovations are unhesitatingly accepted as "progress." The need for organized research into possibilities of an efficient but labour-

intensive technology has frequently been noted. The ILO expert group on employment objectives calls for international action for promotion of experimental research "to develop and disseminate technologies best suited to the conditions of underdeveloped countries, particularly in view of their need to raise the level of employment associated with any given level of employment."

Technology and Programming

So long as the supply of capital to underdeveloped countries is limited, incomes are low, and underemployment and unemployment prevail, the only solution seems to be to assign priorities for projects within a development programme according to contribution to national income, until most of the investment budget is exhausted, but to save some of the budget for useful projects that can be carried out with highly labour-intensive methods. Suppose for example that a Planning Board is confronted with the following group of projects:

| Project | Capital:Labour Ratio ($) | Capital:Output Ratio |
|---|---|---|
| A | 10,000 | 2:1 |
| B | 8,000 | 2.2:1 |
| C | 6,000 | 2.5:1 |
| . | . | . |
| . | . | . |
| . | . | . |
| J | 2,000 | 3.0:1 |
| . | . | . |
| N | 500 | 4.0:1 |

Suppose further that the total investment budget is such that only projects "A" through "I" and one more project can be undertaken. The Planning Board would then be well advised to include Project N rather than Project "J" (or "K", "L", or "M"), in order to make a significant contribution to employment-creation, despite the fact that the total contribtuion to national income over the perspective planning period (it is in this sense that the term "output" should be measured if capital:output ratios are to be used for assigning proirities) is less. In most underdeveloped countries there are opportunities for substantial amounts of employment-creation in this fashion without serious sacrifices in gross national product--opportunities which are not being exploited to the full. Multiple shifts, irrigation and construction works, community development projects, afforestation, village housing, fisheries, and land reform all offer possibilities.

In deciding whether or not such projects are worth while care must be taken to account for labour utilized at social costs rather than money costs. The social costs consist only of any necessary increase in consumption of former unemployed or underemployed who are given work or more work. If their marginal contribution to gross national product exceeds this amount -which is usually very small--it pays to employ them (or to employ them more fully) even though law or convention requires the payment of a money wage higher than this marginal contribution.

## Conclusions

1. In order to make full use of possibilities of raising productivity through application of science and technology, while at the same time reducing unemployment and underemployment, the main requirement is substantially increased levels of developmental investment--the "big push."

2. The occupational and geographic mobility needed to make the most of a "big push" can be greatly enhanced by an appropriate programme of education and training, providing technical, scientific, managerial and entrepreneurial skills for both public and private sectors.

3. While most of the investment budget should be allocated in terms of the contribution of various projects to aggregate national income over the perspective planning period, a part should be reserved for useful projects of a labour-intensive nature. The loss of output involved in such projects need not be great.

4. An international programme of research should be launched, preferably under United Nations auspices, in an effort to produce innovations of a kind that will raise both capital:labour ratios and capital:output ratios.

FOOTNOTES

[1]Cf. Benjamin Higgins,"Economic Development Past and Present" Chapter 10 of Economic Development: Problems, Principles and Policies, New York (W.W.Norton) 1959

[2]International Labour Office. Employment Objectives in Economic Development, Report of a Meeting of Experts, Geneve 1961, p. 49

[3]K.N.Raj, "Appendix I:C India", in International Labour Office, loc. cit., pp. 167-168

[4]Thequestion is dealt with more fully in Volume II of the UNESCO Report on Social Aspects of Economic Development in Latin America, by Medina Echavarria, Benjamin Higgins and H.M.Phillips. (in press)

[5]A.K.Sen Choice of Techniques, Oxford 1960, passim

[6]A.K. Sen, Choice of Techniques, Oxford 1960 passim (Basil Blackwell)

[7]Ibid., p. 114

[8]Ibid., p. 119

[9]These data are all reproduced in the International Labour Office Report on Employment Objectives in Economic Development, (op. cit.) Appendix III.

[10]International Labour Office, loc.cit. p.

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